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## ABSTRACT

We current live in an era, in which data heavily, constantly, and globally flows into all areas of our activities. This mobile world based on the Internet of Things and the concepts of Web 2.0, 3.0 and 4.0, connects us at anytime with our conveniences and contacts, keeps our appointments up-to-date, feeds our information needs, influences our moods, guides our shopping tendencies, and informs us about businesses and opportunities in a way that most of the times it is difficult to manage, due to the massive amount of data involved. Time has come that individuals and mainly organizations have to tackle the problem of how to process large amounts of data in support of their respective needs and operations, aiming at improving their handling and response efficiency. Big Data gives birth to an era, which cannot count anymore with classical database tools to manage and analyze information data-sets. New methods and technologies are required to enable the decision maker to understand and examine the massive, multi-dimensional, multi-source, time varying information stream to make effective decisions, sometimes in time-critical situations. In this work the authors discuss the importance of having appropriate technologies for Decision Making and Decision Support Systems to exploit the potentiality of Big Data analysis, so that organizations can improve their productivity to face increased competition in this new Big Data-Driven Decision-Making era. The study behind this paper also addresses the problem of the current widespread data-centrism tendency for almost all applications requiring decision support, since not all of them have the answers to their problems based only on data.

**Keywords:** Decision Making, Big Data, Analytics, DSS, Decision Support Systems, Internet of Things.

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## 1. INTRODUCTION

The new knowledge era that we currently live in is based on a connected mobile-oriented world, in which data heavily and globally flows into all areas of our economy. Data are growing at an incredible rate and, as estimated in [Lyman and Varian 2003], storage of new information is growing at a rate of more than 30% per year. Further, approximately 2.5 trillion bytes are generated every day within data feeds. Just to have an idea of how the dimensions have increased over time, this same amount of data was produced during the whole year of 2009.

The general aim of decision making in the era of Big data is to reduce large-scale problems to a scale that humans can comprehend and act upon. To this aim there are important challenges that must be addressed [Thomas and Cook 2005]: information scalability, visual scalability, display scalability, human scalability, and software scalability. Moreover, information noise filtering is a great challenge; data security and anonymity is also an important issue to be solved. To tackle Big Data in an effective way, advances and adaptation in technologies and in methodologies are urged. We cannot count anymore with classical database tools to manage and analyze information data-sets.

The aim of Big Data Analytics is to "turn data into insights" for better decision making. The development of data networks and the implementation of massive scale computing, allowed the aggregation and modeling of data at a large scale, leading to the application of the resultant models to decision-making. Key issues, adapted from [Thomas and Cook 2005], to be addressed when developing methods, techniques and tools for Big data analytics are: (a) definition of intelligent reasoning techniques to support assessment, planning, and decision making; (b) specialized data and visual representations, as well as interaction techniques, to help decision-makers to view, explore, and understand large amounts of information at once; (c) integration/fusion techniques that convert all types of conflicting, imprecise and dynamic data to support in-depth data analysis; (d) identify and select techniques to support production, presentation, and dissemination of the results of an analysis to communicate information in the appropriate context to a variety of audiences.

This short paper reproduces the study being carried out by the authors on the theme intiated in [Dargam 2014], in which important challenges for Decision Making approaches to deal with Big Data Analytics are discussed in more details. In the sequel of this paper, we discuss about the Big Data tools and methodologies for dealing with harvesting and analytics. Decision Making is then presented as the logical next step after Big Data Analytics, emphasizing some current differences that should be noticed from conventional approaches and some of the application areas most affected by the Big Data era. Finally, some general remarks and conclusions are drawn about the issues of handling Big Data with relation to Decision Making processes, which is the central topic of this paper.

## 2. Big Data Tools & Approaches

This section presents some of the available tools used to tackle Big Data harvesting and analytics, as well as the methodologies and best practices. The illustration in Figure 1 (from

www.blogs.zdnet.com/Hinchcliffe) summarizes the moving parts involved in the Big Data scenario, with some citations of available platforms and methodologies for the processing of BD harvesting and analytics, envisaging the resulting insights to be applied in DM processes for different business objectives.

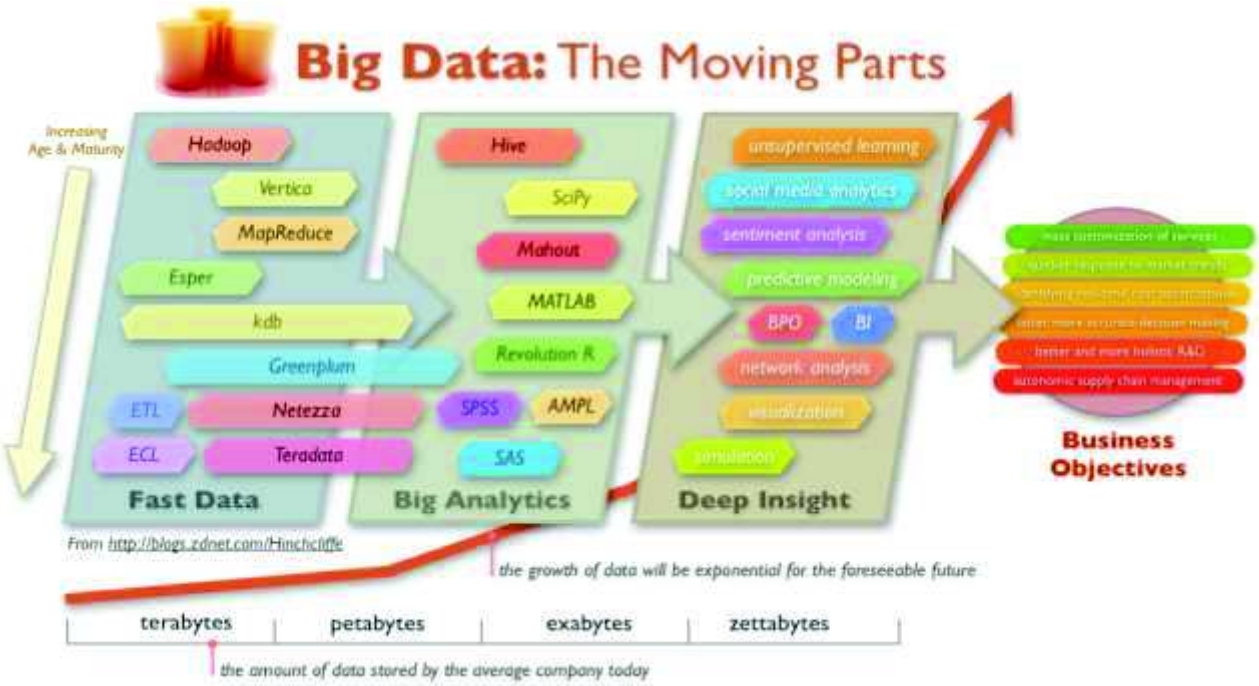


Figure 1: Big Data Scenario (from www.blogs.zdnet.com/Hinchcliffe).

Within a Big Data Ecosystem we can identify some clear phases and processes, like: Data Collection; Data Processing; Data Analysis and Data Execution. Data Collection implies the proper use of Networks, Infrastructure, and Data Centers and Hardware in order to access and analyze a particular set of dynamic data. Data Processing is directly influenced by the technologies used for the Storage and Database management. In this process, the available systems like In-memory (IMDS)[2], NoSQL[3], Hadoop[4], R[5], MapReduce[6], among others are usually considered. Technologies for Big Data harvesting from multiple resources have been fast growing in the forms of data mining systems; search engines; query languages; filtering systems; cloud services, etc. Examples of available Big Data Open Source Tools can be found in [BigDataOpenSourceTools 2015].

## 3. Big Data Analytics and Decision Making

As stated in [Provost and Fawcett 2013], data analytics is gaining increasing attention in business and consequently also Data-Driven Decision-making (DDD), which refers to the practice of basing decisions on the analysis of data, rather than on intuition. Our data-centered

[2] http://www.mcobject.com/in_memory_database
[3] http://www.strozzi.it/cgi-bin/CSA/tw7/I/en_US/nosql/Home%20Page
[4] https://hadoop.apache.org/
[5] http://www.r-project.org/
[6] http://en.wikipedia.org/wiki/MapReduce

world interpretation as well as our data-centered decision-making open up many possibilities, but also involve risks. The main risk of data-centrism is that it encourages the false idea that "whatever the problem, the answer lies in data". In some cases, data analytics cannot deal with ambiguity or imprecision and most of the times it cannot compensate on subjectivity nor replace negotiations. It is our duty to try to combat the purely data-centrism tendency and avoid the dangerous consequences that it may bring.

While organizations have to get ready to cope with high technology standards to face competition in this new Big Data-Driven Decision-Making Era, there is a clear and strong need to enforce the importance of Decision Making and Decision Support Systems to exploit the potentiality of Big Data Analytics, using the appropriate technologies for their applications needs, including also the intelligence implied by decisions that does not always come as a by-product of data insights.

Some DSS application areas, which require interactive and fast-time responsive DM support, were heavily affected by the Big Data era, i.e. mainly the ones including the use of data coming from technical as well as social data-feeds. As examples of such areas, we have:

**a. Collaborative Decision Making Applications**

[Zaraté 2013] has shown that the processes of decision making in organizations have evolved from a cognitive point of view which began with Simon's model [Simon 1977]. It was shown that there is a strengthening of the feedback loops from the last phase – Review – back to the Choice and Intelligence phases. This process has also evolved in organizational terms. We have gone from the context of a single decision maker to an environment with multiple decision makers, who can work asynchronously or otherwise, and apart or together. Therefore, these new decision making processes call for more sophisticated Collaborative Decision making models and technologies.

**b. Dynamic-Temporal-Spatial Applications**

With the advent of "Big Data" and the profusion of information available in the Internet, the dynamic decision process is becoming ever more complex and nonlinear. As [Thomas and Cook 2005] point: "Although massive amounts of information are available from multiple sources, the relevant information content exists in a few nuggets"! There is a growing need for Large Scale Spatial-Temporal Decision Making (LSSTDM) tools capable of handling data and information which are: massive, multi-dimensional, multi-source, time-varying and include embedded uncertainties.

**c. Big Data Analytics in Logistics and Supply Chain Management**

In the current Digital Economy, the emergence of big data analytics has paved the way for developing new tools and techniques to support decision making in logistics and SCM. There are high expectations for big data analytics in logistics and SCM, because existing literature suggests that, in current logistics and SCM practice, decisions are often made using traditional approaches, i.e. data is general collected to test theoretical models built on extensive literature review, experience and opinion from experts [Gunasekaran et al. 2015]. In the current big data era, social media and online data collection and analysis have provided

the potential for real-time and more accurate decisions, which subsequently will provide opportunities to transform the supply chain into a coordinated and integrated supply network, to provide adaptive tracing using RFID across large logistics and supply networks, to assess risk and mitigate disaster through GPS tracking, and to improve demand driven operations through big data predictive analysis.
Future research should explore suitable big data analytical tools and techniques to support supply chains to generate useful insights from big data to drive SCM strategy, improve response time to customers, to reduce time to market for new services, improve supply chain wide decision making process, to enable a full supply chain visibility, ultimately to improve supply chain overall performance [Tan et al. 2015].

**d. Crisis Management, Risky and Critical Applications**

Understanding the risk environment within natural crisis management situations, requires access to key information (most of times coming from legal or governmental entities), for building solution plans to be implemented during a moment of crisis [Stern 2000]. The importance of having access to experts who can make clear the risks associated with a given location, entity, or hazard may mitigate significantly the disaster. Another important factor in the process is the open channel of information coming from different sorts of social networks that are provided by access to Big data networks such as Twitter feeds; Facebook posts; etc.

## 4. CONCLUSIONS & PERSPECTIVES

Big Data promises a fundamental transition in the history of knowledge. If we consider the legality of the situation that needs to be satisfied, we observe that apart from the legal aspects that will have to cover personal data and guarantee individual privacy within the relevant ethics considerations, one shall also be aware of the shift that the collaborative processes are inheriting with all the available data interfering or playing an important role in the decision processes. Reliability, nowadays, also comes through what you search in the Internet. The modern trends and services in a way dictate our moves. One needs to be technologically fit and at the same time to have web-credibility online.

Apart from the application areas considered in this study, there are many DM business opportunities already intelligently using collected Big Data from chains of Open Data. The new services and technological trends already absorbed from the market (e.g.: google glasses, RFID (Radio-Frequency Identification) cards, social media, social networks, web-based games, web-preferences in readings, traveling, hobbies, culture, fashion, e-commerce, etc.), currently supply much more data for analysis than we are ready to exploit in an intelligent and efficient way.

This paper presented a concise survey about Big Data and Decision Making, which covered some decision making application areas that can profit from proper analytics and post-processing approaches to support efficient DM. The research work behind this paper details the important challenges for decision making approaches to deal with Big Data analytics; and addresses the issues concerning the current data-centrism tendency for dealing with applications that require decision support.

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